

A Proposed Microsat Open Experimental Platform for Amateur Space Communications Research

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The SCR-OEP Vision

- The Space Communications Research (SCR) Open Experimental Platform (OEP) is a proposed amateur satellite project
 - Enable and promote space communications research and experimentation by amateurs, students and others
 - Explore the use of Federal research dollars to subsidize amateur satellites
 - Pursue government-sponsored launch opportunities for amateur satellites

The SCR-OEP Vision

- An accessible, dedicated, on-orbit, open experimental platform (OEP) that supports research and experimentation
 - Hosted by dedicated, on-orbit flight computer
 - Support space communications, spacecraft software, flight computer experimentation
- Includes support infrastructure
 - Systems software, ground station, ...

The SCR-OEP Vision

- The SCR-OEP project will benefit amateur satellites and amateur radio
 - Expand support for amateur satellites
 - People and talent
 - Funds
 - Launches
 - Inspire and develop the next generation of scientists, engineers, and satellite designers and builders

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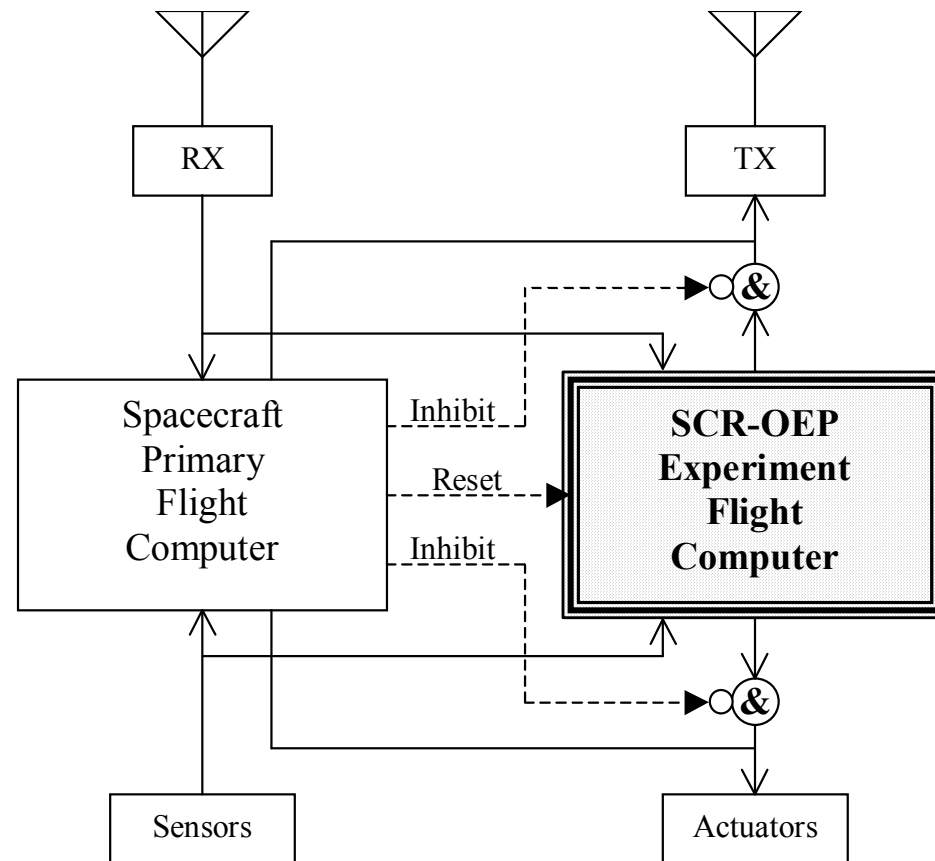
- Hardware Platform
- Software Platform
- Distributed Ground Station
- Experiments and Investigators
- Opportunities for External Support
- SCR-OEP and Amateur Spectrum
- Potential Benefits for Amateur Satellites
- Making SEC-OEP Fly

Hardware Platform

- On-orbit flight computer dedicated to research and experimentation
- Hosted by amateur microsat
 - Microsat provides power, communications
- Not mission critical
- Spacecraft protected from activities of OEP
 - Immature software cannot put spacecraft at risk

Hardware Platform

- Possible hardware platform configuration



Hardware Platform

- OEP has access to spacecraft sensors
 - Permit experiments to use live data
- OEP has controlled access to spacecraft actuators
 - Access under control of primary flight computer
 - Permit flight software to be tested on OEP
 - OEP could back up primary flight computer

Hardware Platform

- OEP will share uplink/downlink bandwidth with other payloads
 - Access to receiver/transmitter controlled/monitored by primary flight computer
- Primary flight computer will control OEP
 - Power (e.g., power down OEP for energy conservation)
 - Reset

Software Platform

- OEP software platform will be based on an open-source, UNIX-like, embedded, real-time operating system (RTOS)
 - Open source
 - UNIX-like
 - Embedded
 - Real-time
 - Software library
 - Candidates

Software Platform

- Open source
 - Affordable and accessible
 - Students and amateurs
 - SCR-OEP development team
 - Modifiable
 - Adapt to needs of host microsat
 - Adapt to general needs of microsats
 - Enable operating system research

Software Platform

- UNIX-like
 - Modern operating system
 - Provide a standard, familiar API
 - Simplify porting of software between systems
 - Leverage UNIX development environments
 - gnu toolset
 - Enable cross-platform development
 - e.g., develop and test on PCs

Software Platform

- Embedded
 - Operate on resource-constrained flight computer
 - Permit tailored load module
 - Contain only what is needed to support flight computer
 - Shrink a large system or design a small system?

Software Platform

- Real-Time
 - Permit rapid response to external events
 - Interrupts
 - Good scheduling capabilities
 - ...

Software Platform

- Software library
 - System software should provide common services
 - e.g., upload, download software
 - support for space communications protocols
 - Need not be complete prior to launch
 - Might be extended as part of experiments

Software Platform

- Candidates
 - RTEMS
 - Recommended
 - Embedded Linux
 - Not real-time
 - RTLinux
 - Dual-kernel architecture
 - Not embedded

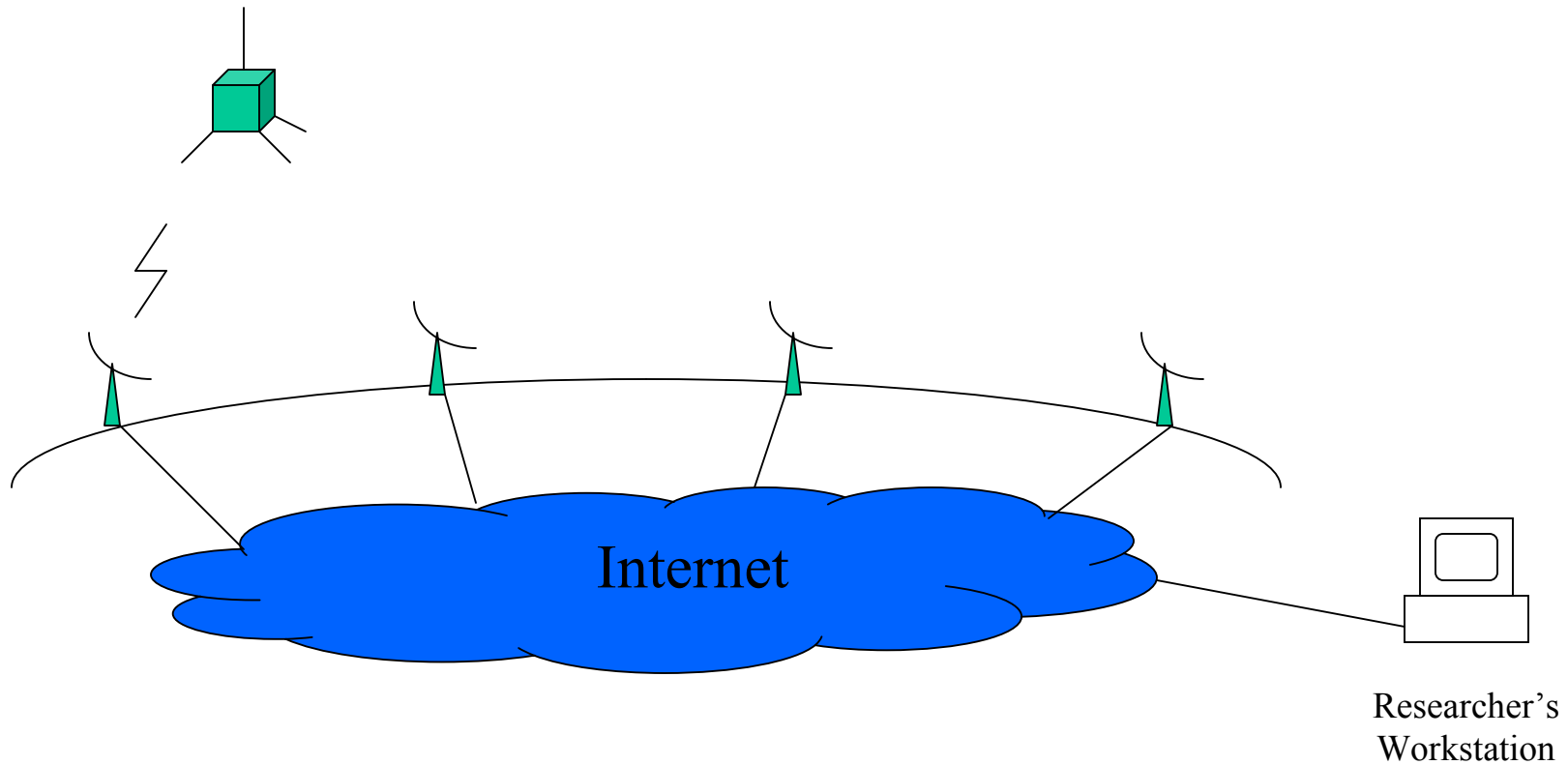
Software Platform

- Real-Time Executive for Multiprocessor Systems
 - Developed by On-Line Applications Research Corporation (OAR) for U.S. Army Missile Command
 - Open source
 - Subset of POSIX 1003.1b (UNIX-like) API
 - Multitasking, powerful scheduler
 - Port of FreeBSD TCP/IP stack (IP, UDP, TCP, ...)
 - Several file systems (in memory, FAT32, FAT16, ...)
 - GNU tool set on UNIX or Microsoft Windows

Distributed Ground Station

- An Internet-enabled, distributed, coordinated system of amateur radio ground stations
 - Provides experimenters Internet-based access to the on-orbit OEP
 - Analogous to NASA's "Internet access to space" concept

Distributed Ground Station



Distributed Ground Station

- Permit ground station to “chase” satellite
- Provide better coverage than individual ground stations
- Allow experimenters without ground stations to participate
- Area of active research
 - NASA’s IP in Space project
 - Considerable work remains

Experiments and Investigators

- Experiments
 - Space Communications
 - The use of the Internet protocols in space
 - Integration of space assets with the Internet
 - Integration of satellites with digital public safety radios
 - Spacecraft software
 - Autonomous, self-diagnosing, self-healing systems
 - Operating systems, real-time, embedded systems
 - Flight computers

Experiments and Investigators

- Investigators
 - Outside investigators propose experiments
 - Investigators need not be associated with project
 - *Anyone* can propose an experiment
 - Experiments Committee selects those with greatest:
 - Scientific merit
 - Relevance to amateur radio

Opportunities for External Support

- Potential sources of external support include:
 - Federally funded research
 - Government-sponsored launches
 - ...

Opportunities for External Support

- Federally funded research grants could potentially support some of these activities
 - Space Communications Research
 - Integration of satellites with mobile networks
 - Integration of satellites with the Internet
 - Spacecraft Software Research
 - Microsats, satellite clusters, satellite constellations
 - Education and Outreach
 - Part of NASA, Air Force mission

Opportunities for External Support

- Government-Sponsored Launch Opportunities
 - Department of Defense (DoD) Space Test Program (STP)
 - “provides spaceflight for qualified DOD sponsored experiments at no charge to the experimenter, via the DOD Space Experiments Review Board”
 - DoD Space Experiments Review Board (SERB)
 - “evaluates the "military relevance and technical merit" of the proposed experiments”

Opportunities for External Support

- DoD Space Experiments Review Board
(continued)
 - “DOD experiments normally originate in the Service (Army, Air Force, Navy, NASA) laboratories or research institutions (colleges, universities, think tanks, etc.) but are in no way limited to these institutions.”

Opportunities for External Support

- DoD STP
 - Used successfully by Air Force Academy, Naval Academy, Naval Postgraduate School to launch student satellites
 - Undoubtedly very challenging
 - Unconventional participant
 - Unconventional approach
 - Stiff competition
 - Launch reportedly require considerable paperwork

Opportunities for External Support

- Developing next the generation of scientists and engineers is critical to our future
 - NASA
 - Mission: “... To inspire the next generation of explorers ... As only NASA can”
 - 2003 Strategic Plan:
 - Mission III: To inspire the next generation of explorers
 - Goal 6: Inspire and motivate students to pursue careers in science, technology, engineering and mathematics
 - U.S. Air Force
 - NASA UCSB grant

SCR-OEP and Amateur Spectrum

- Can this project legitimately use amateur spectrum?
- IARU
 - “Examples of technical investigations relevant to development of radio technique include ...
 - Operational analysis of protocols for digital voice and data communications...
 - Development of spacecraft computers, memory, operating systems, programs, and related items...”

SCR-OEP and Amateur Spectrum

- What other regulatory issues must be examined?
 - Pecuniary interest?
 - Third-party traffic?
 - Others?

Potential Benefits for Amateur Satellites

- Attract, inspire, and develop the next generation
 - Radio amateurs
 - Satellite designers and builders, scientists and engineers
- Develop new satellite technologies
 - Open-source, real-time OS
 - Flight computer
- Expand sources of support for amateur satellites

Making SEC-OEP Fly

- Small Business Innovative Research (SBIR) Phase I proposal submitted
 - Presented as education and outreach project
 - Port RTEMS to next-generation microsat flight computer
 - Design distributed ground station
 - Collaboration with microsat technology vendor

Summary

- The SCR-OEP will:
 - Provide an on-orbit open experimental platform and support infrastructure
 - Explore new sources of support for amateur satellites
 - Attract and engage the next generation

Questions?



Questions

- What experiences have you had with the DoD Space Test Program
- How can AMSAT leverage its tremendous experience and expertise to support education and outreach? Can AMSAT translate this into support for amateur satellites?
- Are you pursuing Federal research dollars? For satellite-related activities?